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A COMPARATIVE ANALYSIS OF PSYCHIC CONTROL AND REGULATION IN AUTOMATA

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- USSR -

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A COMPARATIVE ANALYSIS OF PSYCHIC CONTROL AND REGULATION IN AUTOMATA

- USSR -

/Following is the translation of an article by L. M. Bekker in the Russian-language publication Voprosy filosofii (Problems of Philosophy), No 2, 1963, pages 70-81./

The idea of the uniqueness of the psychic is one of the gnoseological foundations of idealism. For the noncomparability of a phenomenon with any other reality leads to the idea of its substantiality. The proposition of the substantiality of the psychic is inevitably related also with the recognition of introspection as the only method of psychological investigation. Covert forms of these tendencies even now are still persisting in the materialistic science on the psyche. The approach realized through modern cybernetics to the nature of reflection by its very nature precludes the idea of the noncomparability of the psychic and leads to a conclusive surmounting of the traditional errors impeding scientific progress. The cybernetic approach to the problem of reflection unfolds new constructive means for its examination mainly by way of the following two interrelated aspects.

I. The general-cybernetic teaching on the production, transmission, storage, and utilization of information, revealing the quantitative and qualitative, the structural characteristics as informational processes in their various forms and levels, yields a system of concepts which can be used in analyzing psychic processes (in their informational aspects) as a special form of informational phenomena. In so doing we in fact eliminate the dualistic position of the absolute uniqueness of the psychic, uncover a constructive scientific approach for its examination, revealing the specific character of the particular through the general, and giving concrete expression to the most important position of V. I. Lenin on reflection as a general property of matter, in relation to which psychic reflection is its higher, though particular form.

II. The general principles of the functioning of control systems revealed by cybernetics form the basis for a comparative analysis of the regulating function of signals of information at

various levels. In its turn, analysis of how reflection "works" and what are the differences in its working function at its various levels affords a fruitful investigation of methods of organizing reflection processes. This approach is essentially important for still another reason, that it equips investigation with the strictly objective, and in addition with a wholly adequate method of studying psychic reflection. This leads to the actual elimination of the remnants of the introspectionist approach toward methods of investigating the psychic.

The reflex theory of the psychic developed by I. M. Sechenov represented the higher level of voluntary regulation of action as a special case of psychic regulation, and psychic regulation of action itself -- as a special manifestation of the general reflex principle of performance of the nervous system. The general theory of control created by cybernetics, realizing the next stage of scientific generalization was synthesis, represented this reflex regulation of function as a special case of general principle of performance of control system, in which information circulates along a closed circuit. The scheme of the reflex circuit lying at the base of the mechanism of behavior regulation is one of the cases of a control circuit working on the principle of feedback.

Discovering a commonness between the structural system and the functional principle of information circulating in an objectival adaptive or transforming (by labor) effort of man also in operations of automatic systems reveals the real possibility of making a concrete comparative analysis of these systems. The goal of such an analysis is to establish the specific character of the programming and regulating function of psychic processes as information signals in comparison with the regulating function of information signals controlling the dynamics of working operations in automatic systems.

The task of revealing this specific character of psychic regulations of objectival work actions within the limits of an elementary <u>sensory</u> level of regulating systems (sensations, perceptions, and concepts) is the subject of the present article. But it is relevant to this starting level to deal here only with that area of the questions, which is related to the qualitative, structural features of sensory signals and to the role of these features in the control process.

* * *

The principle of programming and the method of regulation realized in objectival work actions of man finds its ultimate expression in the dynamics of the executive organs acting on the object being transformed. The organization of the functions of the working organs that carry out the program of action serves as the most adequate objective indicator of the psychic processes programming and regulating the action. Therefore, the characteristic

of control principles over the objectival action is associated with the specific function of the executive organs of man, chiefly the human hand as an organ of work. The main feature of the human hand as an executive organ compared to the executive organs of any automatic device (including also a mechanical hand) consists in its high functional versatility (related to the number of degrees of freedom), which enables practically an unlimited class of motor tasks to be solved with the same morphologically unaltered structure. The most fanciful special depiction of a motion adequately reproducing the structure of the object being acted upon can be realized by the working points of the hand as an executive organ. The versatility and variability is kinematically limited here only by limits of reach (extent of the motor field), and dynamically -- by the "resistance of materials". Providing the freedom of accomplishing an unlimited diversity of motor solutions, the very design of the hand is not restricted to any specific objectival program of movements. The structure of the hand has neither a program nor individual executive operations built in, still less any algorithmic sequence of such operations.

Serving as functions of reflex effects carrying out action are efferent nerve codes of command information, activating the executive organ and controlling its performance. However, as has been shown by studies of the structure of movements (N. A. Bernshteyn), effector codes cannot serve as the original program carriers for the action realized by the working organs. This proposition is vividly substantiated by the factual material of studies of motor habits, indicating that the development of habits does not occur through formation of a fixed sequence of movements, as it needs must occur if the program carrier of the actions was the effector command information.

We must, therefore, conclude that the programming of objectival work actions of man and the specific character of their regulation must be sought for in the structure of the guiding [osvedomitel'naya] information inherent in the original regulating function.

The objectival structure of the executive acts of man derived from the objectival structure of the psychic processes, which are the signals of the guiding information regulating the action. It is precisely this function of sensory imaging that I. M. Sechenov pointed to when he wrote that "sensation is everywhere a regulator of motion."

The process of technical progress and mechanization of labor has interrupted the reflex circuit of elementary objectival action and has interposed between the executive organs of man and the final object of labor activity an ever-increasing intermediate links. Technological, power, and transport functions of human activity have been wholly converted to machine links of the control circuit. Left for the actions of man's working organs is the function of control. Man has become the controlling link of the system. Controlling action is increasingly being reduced,

and in relation to the ultimate object of working activity, is increasingly losing its developed objectival structure, being turned into a signal-code of command information (motor reactions of the operator at control panels). With the transition from direct control by machines to remote control, the objectival character of this control and the guiding information is being displaced and lost, the guiding information being received by the operator in coded form as various kinds of indications (instrument dials, sign indications, diagrams on charts). However, losing its directly objectival character <u>in relation to the ultimate object of labor</u>, man's perception and action wholly retain its <u>objectival structure</u> in relation to their direct objects -- the indicating equipment and the control organ. This objectivalness of the structure of perception and action in relation to their direct objects lies at the basis of the versatility, generalizability, and relative universality of the controlling operations of man, which are a particular case of the general variability and universality of human <u>objectival action</u>.

Thus a contradiction has arisen between the code character of guiding and command information in relation to the <u>ultimate</u> object of action and the objectival structure of perception and action in relation to their <u>direct</u> objects. This contradiction lies at the basis of two opposing trends in the development of modern systems of remote control over production processes. The first trend consists in the guiding information in control systems becoming similar to the directly objectival forms (three-dimensional diagrams, tele- and radio-locating representations, etc.) and the imparting of the highest possible structural commonness of the sensory and motor components of action. This trend of making the controlling operation similar to the functional scheme of objectival action derives from man's requirements as a link in the control system and is related to the need for preserving these functions for him. The second trend in the development of remote control systems is manifest in the effort to replace the structure of guiding and command information and operation by signals of coded information based on specific algorithms. Carrying out this trend will lead to the automation of man's controlling operations, that is, to the development of systems of automatic control.

This line of development aimed at displacing the guiding and command information find its high point in the principles of automatic system functioning. From this point of view it is not a chance matter that in technical systems information transmitted in the form of codes is decoded only in those communication channels at the exit of which the information is received at a sensory access point of man (televisor, a radio-locater). At the exit of such channels the coded information, being decoded, is converted into an image. In systems of automatic control, however, guiding information undergoes only recoding and is nowhere converted into images. This is the essential feature of such systems.

Another fundamentally important characteristic of control principles in automatic systems is that, in spite of the tendency to be free from the fixed character of the program in the design and to thus make for the universality of the system, the program of system performance still remains as it were partially fixed in the design. In particular this refers to the program of elementary operations built into the design of the system's working organs. In various control systems there is a different distribution of program components between the system design and the information entering the system. But even in those program parts, which are given by information, the elemental <u>relationship</u> of each value of the guiding information signal with the states of the controlling executive organ corresponding to it is determined by the design (for example, in automatic control systems by the flash of zenith artillery).

From this point of view it is very indicative that the use of universal computers as components of automatic control systems is complicated by the fact that they require appropriate equipment for intake and outflow of information, but the <u>design</u> of the latter depends essentially on the specific character of the automatic system. It is also important in this regard to note that in the single type of automatic systems with unfixed design (which thus does not feature a set program), in the so-called indeterminate self-organizing systems, the control process is accomplished on the basis of random search or on a "trial and error" method. The total absence of a fixed specific program in the design thus condemns the system to the way of blind search (finding ways of optimizating, which is presently the object of numerous investigations).

The indicated features of principles of control realized in automatic systems on reasonable grounds considerably restrict the versatility, the interference-proof character, and the reliability of functioning of theses systems.

* * *

The goal of a comparative investigation of the main characteristics of the sensory regulation of human actions and of a study of control methods in automatic systems consists in discovering the differences between these two categories on the basis of those <u>general</u> <u>principles</u> of control, whose specific particular manifestation constitutes both kinds of control under comparison.

Analysis allows us to discover an essential difference in the interrelationship of information and design in the process of carrying out a program of operations by man and by an automatic system. As was indicated, in its very design the automatic system has partially built in the program for carrying out its operations. In the first place, this refers to the system inherent in the working organs, the very structure of which is built into

the program of the corresponding executive operations. The design entails in itself fixation and other program components in various automatic systems, as occurs for example in systems using analogue computers, whose design entails in its program the transformation of information incoming to the system.

In man the design of his working organs and all the other links of the reflex mechanism of objectival action does not introduce any individual specific program. The role of design consists here in that it sets up the morphological foundation for possibilities of carrying out any objectival kinematic structure of action.

A program of actions or operations ultimately is determined only by two factors -- the design of the system or the characteristics of the information circulating through its circuit. Therefore, the differing roles of design in programming operations in both systems can be related only to the different characteristics of information in these systems. Quantitative characteristics of informational processes occurring in both systems in themselves cannot serve as the basis for the differences in the role that design plays which are of interest to us. In regard to the passing capacity and rate of operation performance the advantages are clearly held by automatic machines. More improved controlling functions of informational processes not requiring that programming be based on system design would scarcely derive from a restricted passing capacity and speed of operation that man displays compared to the automatic machine. Based on this, the existence of the fundamental differences referred to between the systems under comparison in distributing the program between information and design inevitably leads to the conclusion that the differences in the role that design plays in realizing the program can be found only in the substantial difference in qualitative structural characteristics of the information signals circulating in the system and inherent in the specific program itself.

Analysis of the functioning of all the main kinds of control systems supports the conclusion that in systems of rigid control and in regulating systems, as also true in self-adjusting automatic systems, the information signals inherent to given program components exist in the form of continuous or discrete codes.

This conclusion derives directly from the characteristic of those transformations of information which occur in sensory cell-pickups /element-datchik/, in central amplifying converter links of the regulator, and in executive equipment. From the very essence of the physical characteristics of these processes we find that coding of the incoming information occurs here into the alphabet of the communication channel, which is a member of the control circuit. Circulating along the circuit, the information undergoes several recodings, leaving it, however, in a coded form.

In the objectival actions of man the ultimate stage of the conversion of command information is represented by the

systems of movements carried out by the "working point" of the executive organs which draws near the object and acts on it. From their very nature these motor structures are similar to the object and to the ultimate product of action, and in this sense they are not a code but a motor reproduction of the object's structure. Such an objectival character of the motor structures of human action cannot be determined, as has been mentioned, either by the design of the executive organ, for they have no concrete program inherent to them, or by the codes of the executive effector information, for these codes are not fixed in the establishment of habits with action. The source of this objectival character of the motor structure here can only be the guiding information. In order that signals of the latter can give and adequately receive objectival programs of action, the signals themselves must inevitably be the representation of objects of these actions as they occur and in the final state. No other source and carrier of the objectival program of action, nor its adequacy to the object has analysis here been able to discover.

The presence of the necessary conjunction of the code form of information with the partial fixation of the program in the system designed, and in particular in the structure of its working organs, indicates that in and of itself information circulating in the form of codes cannot wholly supply the geometrically objectival, and kinematic characteristics of the working operations. Therefore, the part of the program which cannot be determined by information must be fixed by the design. In distinction to this information signals having the form of objectival images program and regulate the entire structural kinematic characteristics of human action without the support of a program built into the design. The design foundation here consists in revealing the biomechanical and psycophysiological possibilities for realizing any program of objectival working and controlling operations. Such essential differences in the regular defunctions of these two forms of signals are obviously related to the fundamental differences between representation and code in the very form of their organization.

Every signal of information is a set of states or elements, ordered appropriately to the set of elements of the information source. It is precisely this preservation of the corresponding orderedness of its states that makes the signal the carrier of information of its source. But the distorting effect of any noise or interference consists precisely in disarranging the corresponding orderedness of the signal elements.

Based on the nature of the information signals as a definitely ordered set of elements, there is reason to believe that the differences between code and representation as forms of information signals must lie along the line of the properties of the original elements and the character of how these elements were ordered in the set. From this point of view the essence of the code form of information signals is clear enough. Here the only requirement for the set of signal states is an isomorphic

correspondence to the set of source elements. The essence of isomorphism consists, as is known, in the pairwise single-valued correspondence of the elements of one set to the elements of another set and the pairwise single-valued correspondence of the transformation operations determining the conversion from one element to another in both sets. As to the physical properties and spatio-temporal characteristics of the elements of both sets isomorphism in general is indifferent. But as to the method under which the elements of both sets are ordered isomorphism presents no other requirements besides that of the single-valued correspondence referred to. Under the conditions that this correspondence is preserved the internal structure of the set, the spatio-temporal organization of its elements, can be arbitrary, since its changes do not affect the essence of the isomorphic relationships. Since it is specifically this single-valued correspondence of the elements of two sets and their transformations that make the set of elements of the information signal a <u>code</u> of its source, the condition of isomorphism is a necessary and sufficient determinant of the code nature of the information signals.

In regard to the information signals organized in the form of images, the situation is substantially otherwise. The isomorphism requirement is unconditionally necessary also in relation to the <u>image</u>, for it is general for any kind of information signal. Without the isomorphic relationship of the sets there is no information signal. But, though necessary, this condition is not here sufficient. In order that the information signal be not only a code, but also an image, its characteristics must include additional requirements. Analysis shows (cf L. M. Vekker and B. F. Lomov, "The Sensory Image as Representation," <u>Voprosy filosofii</u>, No 4, 1961) that such additional requirements also affecting the properties of the elements of the set constituting the signal, and methods of ordering these elements reduce to the following. In order that the information signal be not only a code of its source, but an image of any of its properties, it is first of all necessary that the properties of the elements of the set forming the signal be reproduced by the corresponding physical characteristics of the elements of the set comprising the source, and in the second place, that the spatio-temporal orderedness of the elements of the set forming the signal not only isomorphously correspond to the orderedness of the set of elements constituting the source but also adequately structurally reproduce this orderedness, as occurs, for example, in photographic or television images. Observance of both these additional requirements also makes the information signal a <u>representation</u> of the object.

Since the representation satisfies the conditions of isomorphism, it still remains a code, but here the commonness shared by the requirements additionally stipulated for the signal which is a representation gives rise to substantial differences between the representation and the code. Thus, isomorphism, a necessary

and sufficient general condition for the code form of the signal, does not stipulate any requirements in regard to the dimensionality (number of measurements) of the set of elements forming the signal, or of the set of elements forming the information source. For example, a three-dimensional volumetrically spatial set of elements forming a physical object of specific size and form can be coded in a two-dimensional or one-dimensional set of elements varying in their features. And change in the dimensionality of the signal-code compared to the source can never disturb the character of the code relationships. The situation changes fundamentally for the signal-representation. Change in the number of measurements of a set forming the signal compared with the set-source attacks the nature of the adequacy of the representation. Thus, if the television exposure, being a two-dimensional set, is drawn into a line, then it clearly loses its property of image, and, therefore, remains a code. Analogously, the code relationships of two sets freely permit conversion from the spatial orderedness of the elements to a temporal, and vice versa.

Thus, in distinction to the code form of information signals the makeup of a signal-image requires the preservation of invariancy of the general orderedness of the elements in the conversion from the set-source of information to the set forming its signal. But the invariancy of the total structure or orderedness of the elements is related to the preservation of the invariancy of the number of measurements of the correlated sets /See Note/. Superimposing the additional restrictions indicated on the orderedness of the image elements defines another method of organizing the signal, under which the latter contains reproduced not only a measure of orderedness (that is, a quantity of information determined by the isomorphism of the signal and the source), but also its concrete form.

(/NOTE/ At this point, further strict analysis of the specific character of the image as an information signal compared to the code will lead to the formulation of a mathematical problem of finding such classes of transformation, in relation to which the adequate internal orderedness of the set elements and the dimensionality corresponding to it (number of measurements) would remain invariant.)

All these indicated differences between the signal-image and the signal-code "operate" in the process of carrying out the realizing function of the signal, that is, in the transformation of guiding information into command.

The requirement of isomorphism extends not only to the relationship of the information signal to its source, but also to the relationship of the guiding information to the command. The condition of isomorphism applicable to the code form of information signals is necessary and sufficient both in regard to their guiding as well as to their operating, regulating function. The isomorphic relationships between the guiding and the

command information determine the element-by-element, pairwise correspondence of the values of both signals. But they neither set nor determine the principles of internal orderedness of elements in the sets forming the signals of guiding and command information. Therefore, the principle of the orderedness of the signal elements, which signal would determine the objectival structure of the executive reactions, the adequate object of action, cannot be set by the code form of the signal. This stems from the very nature of the code form of information, which is indifferent to the internal orderedness of the elements of the correlated sets and requires only their single-valued correspondence. Since the code form of information signal does not consist in the integrally objectival, structural characteristics of the information source, being at the same time the object of action, it yields no sort of spatio-geometric and spatio-dynamic foundations for programing routes of motion of the working organs. Not containing a single-valued spatio-geometric structure, the code cannot of itself provide the kinematics of motion of the executive organs. It is precisely because of this that the realization of the program of operations in automatic systems, since they operate with the code form of information signals, must be based on geometrical characteristics of the program being built into the design of the system. In this way the program components are set in the design of the executive, working organs of the system and in accordance with the design of the executive elements of the automatic regulators. As to the regulating function of the image-signals the situation turns out substantially different.

The nature of the relationship between command information and guiding derives from the relationship of guiding information to its source. Just as for the case of the relationships of image-signals to the information source, for the relationships of command information to guiding information existing in the form of images the condition of isomorphism of the sets of elements is a necessary, but an insufficient determinant of the mutual relationships. As was shown, for the image in comparison to the code there is not only a pairwise correspondence between the elements of the signal and those of the source, but also a commonness of the principle of their spatio-temporal orderedness. Correspondingly, in distinction to the code-signals between command and guiding information we require here not simply an element-by-element correspondence, indifferent to the orderedness of the elements within each of the sets, but a commonness of the principles of their orderedness. Deserving the properties of the elements and the adequate source of information, their orderedness, the image reproduces the physical and the spatial structure of the objects. And exhibiting the dynamic and geometric objectival characteristics, the image can set the spatial characteristics of the routes of motion realizing the operation with this object. The objectival-structural dynamic and geometric characteristics of the image determine its kinematics of operations

directed toward the object. Here, the geometry of how the object is represented against the background of a specific spatial situation and the kinematics of how the object is dealt with are correlated not only element-by-element, but also structurally.

In carrying out the regulating function through code signals of information, the command and the guiding information are correlated to each other as two sets, being codes of the information source -- the object of action.

Under an optimal realization of the regulating function of the image-signals, the guiding information and the ultimate form of the transformations of the command information -- the system of movements -- are correlated to each other as two sets, whose orderedness reproduces the structure of the object of action. And this means that not only each element of the projectory of movement can be single-valuedly compared with the corresponding element of the image, but also that the motor structure as a whole reproduces the orderedness of the image elements, and through the agency of the latter, the structure of the object of action as well. The geometry and topology of the image of the object and the conditions of action contain potentially the routes of the possible movements realizing the operation on the given object. Thus, for example, a psychic image of a perceived or represented object contains in itself the routes of movements for reproducing this object (in a drawing, in marble, etc.). In more complex instances and in the general case the kinematics of movement derive not only from the geometric or topological, but also from the power components of the image. But the power components of the image, even though they do not coincide with the elementary geometrical logic of the object (they "do not lead there", from the expression of N. A. Bernshteyn), are organized in spatio-objectival structures determining the kinematics of the corresponding motor operations.

This is expressly why, in distinction to code-signals that information-signals organized in the form of images cnn program and regulate the motor functions of the executive organs without depending on specifically geometric components of the program being built into the design of the system.

From this derives the principle of the correlation of information with the design of the system, the principle consisting in the fact that the design of the controlling system of psychic regulation, not being fixed by any definite program of specifically executive or controlling operation, unfolds within definite limits optimal possibilities for realizing any objectival program of transport, technological, or controlling operations. This is also related to the absence of any transcription of a program of executive and controlling operations in the design of the executive organs of man, as well as being related to the universality of his executive and controlling functions.

The problem consists in how, from the above characterized principle of programing and regulating of actions by image-signals,

to derive the main specific features of psychic control in comparison to regulation of operations in automatic systems.

The present analysis makes such a step possible only in a most general form, applicable to several of only the most essential stages.

1. The absence of any fixed character of the program of action in the executive organs and the fact that this program is derived from the guiding information organized in the form of images is expressed in two interrelated points: a) the same executive organ of man (for example, the main executive organ -- the hand) can realize an unlimited diversity of objectival-motor programs, b) the same program, yielding the structure of the image-signals directly forming in the process of perception or being the product of its intellectual treatment can be realized by various executive organs (cf N. A. Bernshteyn, O postroyenii dvizheniy [On the Structure of Motions], Moscow, 1947, page 91). Both the universality of the motor programs realized by the same organ, and the indicated broad replaceability of the executive organs carrying out the same program derive clearly from the absence of any fixed character of the program in the design of the organ and from the method of obtaining the program, under which it is wholly drawn from the objectival structure of the image-signal. Exhibiting, in distinction to the code-signal an orderedness of its elements adequately reproducing the structure of the object of action, and containing in itself the routes of movements carrying out the corresponding operations, the image-signal forms the kinematic of functioning of not just one, but within the limits of any executive organ (to the extent that a sufficient number of degrees of freedom exists).

2. The image of the object and the conditions of action reproduce the geometry of three-dimensional space or two-dimensional surface. The route of movement realizing the attainment of this object is always a line, forming in some way in the structure of the given region of space or the given surface. But the structure of the given region of space or surface includes not a single trajectory of possible movement, but an entire family or unlimited set of lines lying on the given surface. Even in the case in which the image of the object is a line, for example, the line of a contour, this single line of the contour contains in itself a set of various trajectories lying on it, reproducing the same total contour. Thus, the geometry of the image of the object and conditions of action, including also energetic, force components, potentially determine the kinematics of an entire family of routes of movements realizing the attainment of the given object. From this correlation between the geometry and the topology of the image of the object and (the conditions) of action, on the one hand, and the kinematics of the corresponding trajectories of movement, on the other, derives such an essential characteristic of psychic control, its variability.

3. From this same general principle derives another main feature of psychic control, also intimately related to variability, its generality. There are two main forms of the generality of motor behavior:

a) the generality of motor responses under an unaltered general situation of action (the response of generalization),

b) the generality of actions in a transition from one situation to another (the stimulus of generalization).

The first form of generality, that is, the generality of motor responses, consists in that the same motor task under an unchanged general structure of the objectival situation can be accomplished by various approaches, using various routes of movement and procedures of action.

The spatio-temporal structure of the objectival image of the situation of action includes, as was indicated, an entire family of routes of movements, contained in the general geometrical-dynamic structure of the image. In each individual case of realization of the motor solution, a selection is made of one of the routes and corresponding procedures contained in this image structure. Since with an unchanged situation of action the regulating image remains the same, correspondingly the total structure of the signal of guiding information from which the selection of a given variant is made is likewise preserved.

Thus, the generality of reactions here is the constancy of the image of the objectival situation with variation of the kinematic characteristics of individual motor solutions potentially contained in the image structure.

The second form of generality of psychically controlled motor behavior -- the generalization for stimuli -- is expressed in the transfer of motor habits from a situation to a situation where their objectival structure shares a commonness, that is, here a singling out of common components of the image occurs.

Both of the examined forms of generality of psychic control characterize the process of building motor effects (specifically excutive or controlling) not as a selection and treatment of a fixed order of motor acts, but as the formation of a sonco-motor structure, in which the sensory image-signal builds its motor components.

4. From the characterized features of psychic control stems another of its main characteristics, redundancy. The essence of the latter consists in that the regulating image-signal determines the possibility of accomplishing not only that variant of movement which has actually been selected, but the entire family of these variants, whose kinematic characteristic corresponds to the geometry and topology of the objectival image. In regard to the actually realized solution, the potential possibility of all its other variants deriving from the general structure of the image-signal is redundant.

If the realization of the selected variant from some external or internal cause cannot be achieved, then the existence of methods of solution redundant in relation to the given variant provides for the possibility of its replacement. Here, such a replacement can easily be achieved (under the regulating action of the general structure of the image) both before the selected variant of motion begins to be realized, as well as in the midst of its accomplishment.

5. All these redundant possibilities of replacement and change-over also determines such essential features of psychic control, as its interference-resistance and reliability. Interference-resistance derives from the integrity of the image, and the reliability of realization of a certain operation under changing conditions (not allowable with systems operating from a code form of information signals) here stems directly from the diversity of the variants of motor solutions, determining the general objectival structure of the image.

All the enumerated features of psychic control find their ultimate and general expression in such basic characteristics as relative universality and versatility, manifested to the same extent both in specifically executive and controlling operations.

The analysis presented shows that all phenomenalogically known characteristics of psychic control, in distinction to the characteristics of regulation in automatic systems, actually stem from differences in the methods under which those signals of information which carry out the process of control are organized.

The method of ordering the image-signal elements in distinction to those of the code-signal, reproducing the objectival structure of the information source -- the object of action, determines those features of interrelationship of guiding information with command which elements are expressed in the above-listed basic forms of psychic control.

* * *

The organizedness of elements of sensory signals in the form of objectival images (in distinction to code-signals) revealed by analysis of the regulating functions of various levels of signals confronts science with the task of further studying the mechanism of reflexive dynamics of analyzers, realizing the formation of the sensory image as an image-signal.

Modern knowledge of the analyzer as a feedback system and our understanding of the sensory image as the effect of reflexive acts of this system enables us to examine the structure of the image-signal as a process of the synthesis and ordering of the set of elements forming the signal into an adequate source of information of integral structure.

Particularly urgent problems in this investigation relate to that link of the analyzer mechanism which provides for the transition from a frequency-impulse nerve code to an image-signal,

that is, which accomplishes the operation of decoding. Discovery of these mechanisms will enable us to advance to the next stage of analysis -- discovery of the mechanisms by which guiding information is transformed into command information, these mechanisms lying at the basis of the concrete realization of the working function of a sensory image.

Thus, analysis of the real living function of the process of reflection will lead to singling out its specific structure, and discovery of the latter will again permit, although on a more profound basis, investigation of the mechanisms of its working, controlling functions. Here, the practical action of man at the given phase of analysis emerges as the objective criterion and the source for comprehending the very process of perception as a process of reflection or representation in the proper and precise sense of this term.

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